Track reconstruction efficiency

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Tralgo Meeting
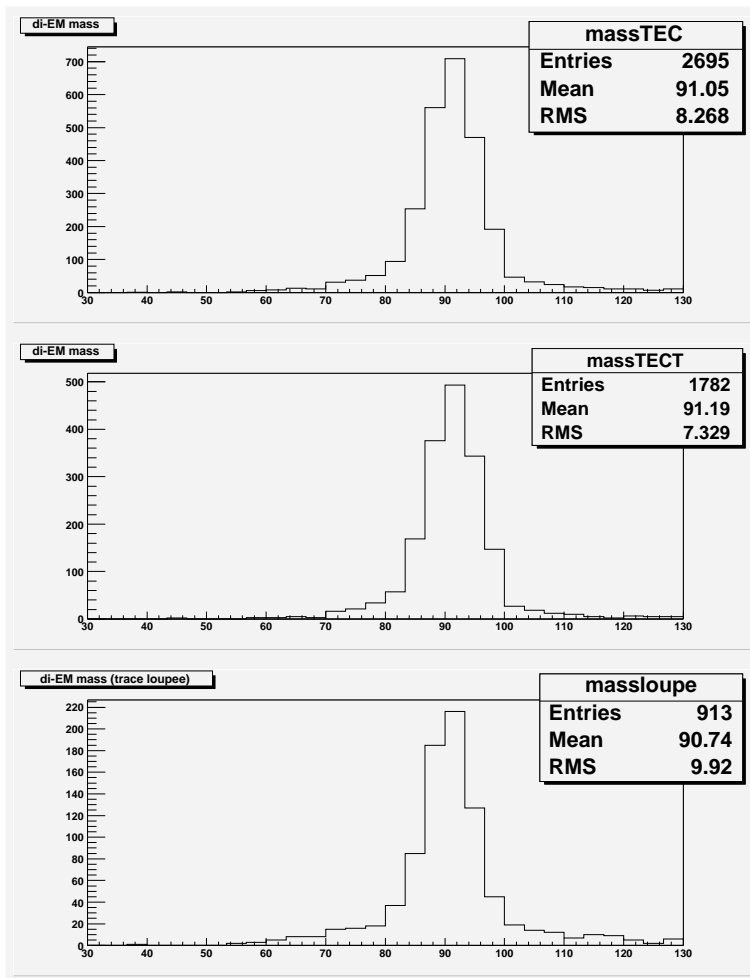
http://www-d0.fnal.gov/˜rakitin/d0_private/tex/2006.Jun.01.Tralgo/tr.pdf

Tracking efficiency study:

Reminder: I use Jan Stark's data sample $Z \rightarrow e^+e^-$:

- One EM cluster in CC ("tag electron") – must have matching track
- Another EM cluster in end-caps ("probe electron") – does not have to have matching track

di-EM mass

massTEC	
Entries	2695
Mean	91.05
RMS	8.268

di-EM mass

massTECT	
Entries	1782
Mean	91.19
RMS	7.329

di-EM mass (trace loupee)

massloupe	
Entries	913
Mean	90.74
RMS	9.92

The plots of di-EM mass (© Jan Stark):

- Upper: all events
- Middle: probe electron has matching track (~66%)
- Lower: probe electron has no matching track (~34%)

- **Problem:** matching track isn't reconstructed for probe electron in one-third of cases
- **Resolution:** slight change of reconstruction algorithm may help

Method of study:

- Shoot an imaginary track from PV to EM cluster
- See which hits are close to it
- Understand why they were not composed into track

In my study I only use first 85 events from the sample in the lower plot

Tracking efficiency study:

- **Idea:** allow tracks to have hits in both SMT barrels and SMT disks

  $\Longrightarrow$ inefficiency $\eta = 1 - \varepsilon$ decreases by **13%**

- Increased 3σ window around track up to 4σ

  $\Longrightarrow$ reconstructed 8 tracks out of 44 (inefficiency decreases by **18%**)

- Increased the sample from 44 to 85 non-reconstructed tracks

  $\Longrightarrow$ reconstructed 10 of them (inefficiency decreases by **12%**)

- The added sample of 41 track has lower fraction of reconstructed tracks

- Would be interesting to check in MC if number of fake tracks increased

- Total number of tracks per event increased by **37%**
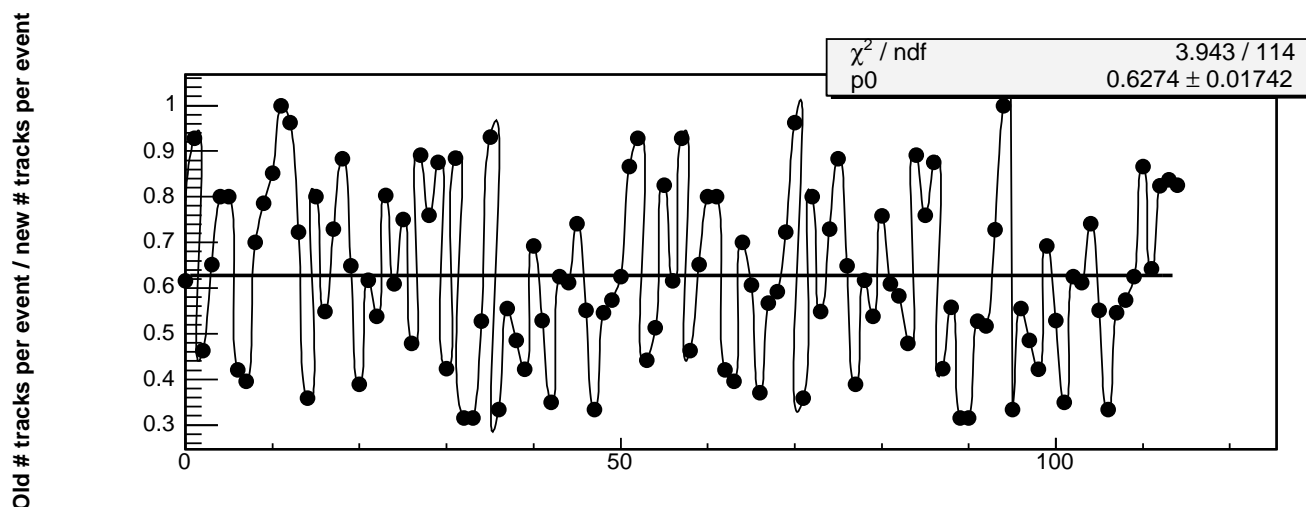
Timing study:

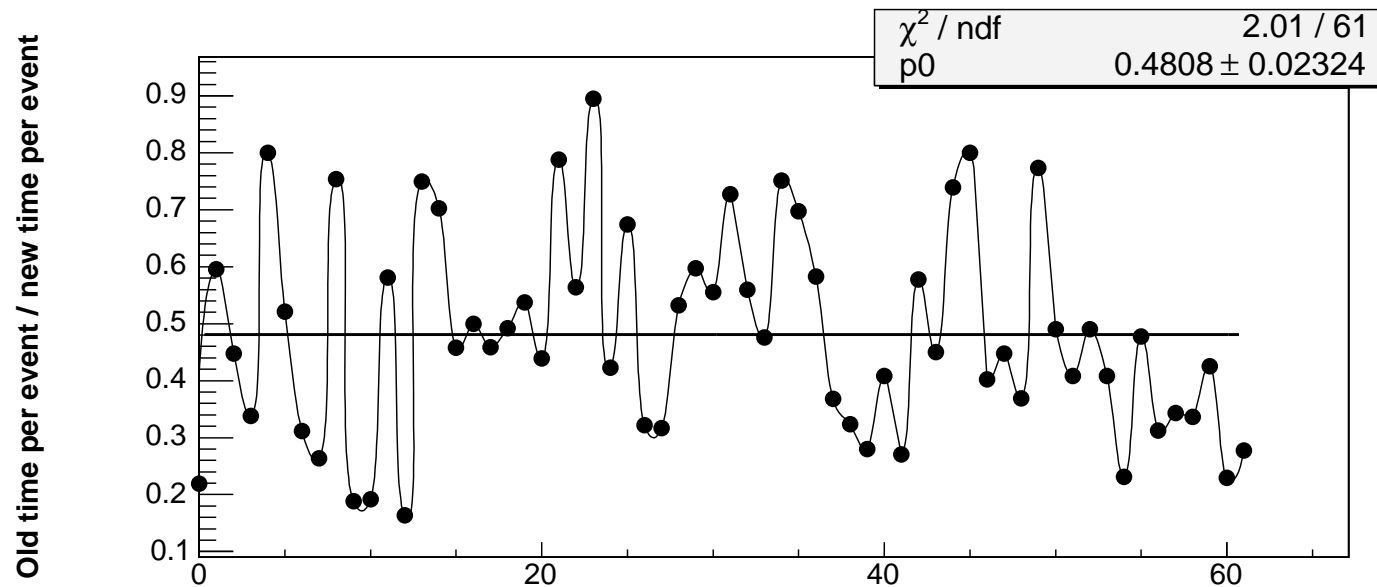- Tracks with hits in SMT barrels were checked for match in *z* only
- Tracks with hits in SMT disks were checked for match in *r* only
- Combination must be checked for both matches $\Longrightarrow$ significant timing increase

Fit ratios $\frac{\text{old time}}{\text{new time}}$ with horizontal line $\Longrightarrow$ Time increases by factor of ≈ 2

Seem to stuck with this number...

Tracking efficiency in detail:

- All the tracks having 3+ hits in SMT barrels or SMT disks are reconstructed with current algorithm
- Non-reconstructed tracks (85) can be divided into 5 categories:
  - ☞ Tracks with

    either 2 hits in SMT barrels and 1-2 in F-disks

    or 1-2 hit   in SMT barrels and 2 in F-disks

    (24 tracks out of 85)

  - ☞ Tracks with 2 hits in SMT and 4+ in CFT (9 out of 85)
  - ☞ Tracks with hits being further than "standard" 4σ window (12 out of 85)
  - ☞ "Invalid" tracks with too few axial or stereo hits (5 out of 85)
  - ☞ Tracks with too few hits to be reconstructed (35 out of 85)

By changing algorithm we can reconstruct a few tracks in first three categories

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"2+1" or "1+2" or more SMT hits:

Run/Event	Electron	SMT Barrels	CFT	SMT F	SMT H	Reconstructed?	Reconstructible?
164605 10233199	Probe	2	3	2	0	YES	Yes
	Tag	6	7	0	0	Yes	Yes
165805 2576564	Probe	2	2	2	0	YES	Yes
	Tag	0	7	1	0	Yes	Yes
165906 6603711	Probe	2	3	1	0	No, hits too far	No
	Tag	4	7	0	0	Yes	Yes
166113 39215346	Probe	1	3	2	0	YES	Yes
	Tag	4	8	1	0	Yes	Yes
166295 20638511	Probe	1	0	2	1	No, invalid	No
	Tag	3	8	0	0	Yes	Yes
166302 24938931	Probe	2	3	2	0	No, hits 8 σ away	No
	Tag	3	8	0	0	Yes	Yes
166302 24109618	Probe	1	3	2	0	YES	Yes
	Tag	4	8	0	0	Yes	Yes
166506 46965463	Probe	2	4	1	0	YES	Yes
	Tag	2	8	0	0	Yes	Yes
164445 2159216	Probe	1	1	2	0	No, invalid	No
	Tag	2	8	2	0	Yes	Yes
166782 123665141	Probe	1	3	2	0	YES	Yes
	Tag	3	8	0	0	Yes	Yes
164605 7263701	Probe	1	3	3	0	No, hits too far	No
	Tag	2	8	0	0	Yes	Yes
164041 21879237	Probe	0	0	2	2	YES	Yes
	Tag	2	8	1	0	Yes	Yes
166835 18381547	Probe	2	1	2	0	No, hits too far	No
	Tag	4	8	0	0	Yes	Yes

"2+1" or "1+2" or more SMT hits:

Run/Event	Electron	SMT Barrels	CFT	SMT F	SMT H	Reconstructed?	Reconstructible?
166937 9714345	Probe	2	2	2	0	No, hits too far	No
	Tag					Yes	Yes
167325 3178494	Probe	1	1	2	0	No, hits too far	No
	Tag	5	7	0	0	Yes	Yes
166992 23278575	Probe	1	0	5	1	No, hits too far	No
	Tag	4	8	0	0	Yes	Yes
168562 3177272	Probe	1	3	2	0	No, hits too far	No
	Tag	3	8	0	0	Yes	Yes
168498 519484	Probe	1	2	2	0	No, hits too far	No
	Tag	2	8	0		Yes	Yes
168691 4204765	Probe	0	0	2	1	No, hits too far	No
	Tag	1	8	0	0	Yes	Yes
168973 5391969	Probe	2	2	1	0	No, invalid	No
	Tag	2	8	0	0	Yes	Yes
168733 20618630	Probe	2	2	2	0	No, hits too far	No
	Tag	4	8	0	0	Yes	Yes
168959 2815665	Probe	2	2	2	0	No, hits too far	No
	Tag	4	7	0	0	Yes	Yes
169224 3001153	Probe	0	1	2	1	No, hits too far	No
	Tag	0	8	0	0	Yes	Yes
169640 3952173	Probe	2	6	1	0	YES	Yes
	Tag	5	8	0	0	Yes	Yes

2 SMT hits and 4+ CFT hits (not investigated yet):

Run/Event	Electron	SMT Barrels	CFT	SMT F	SMT H	Reconstructed?	Reconstructible?
165977 6659303	Probe	2	4	0	0	No, 3-hit req.	Yes?
	Tag	0	5	0	0	Yes	Yes
166313 32787929	Probe	0	4	2	0	No, 3-hit req.	Yes?
	Tag	2	8	0	0	Yes	Yes
163171 48542536	Probe	1	4	1	0	No, 3-hit req.	Yes?
	Tag	0	8	0	0	Yes	Yes
163171 46651698	Probe	0	4	2	0	No, 3-hit req.	Yes?
	Tag	1	8	0	0	Yes	Yes
164039 14995544	Probe	0	6	2	0	No, 3-hit req.	Yes?
	Tag	3	8	0	0	Yes	Yes
166869 37137074	Probe	0	5	2	0	No, 3-hit req.	Yes?
	Tag	0	8	1	0	Yes	Yes
166868 36065427	Probe	1	4	1	0	No, 3-hit req.	Yes?
	Tag	3	8	0	0	Yes	Yes
167662 67087731	Probe	0	5	2	0	No, 3-hit req.	Yes?
	Tag	2	8	0	0	Yes	Yes
169001 3373246	Probe	0	4	2	0	No, 3-hit req.	Yes?
	Tag	1	8	0	0	Yes	Yes

Hits too far from track (with non-changed algorithm):

Run/Event	Electron	SMT Barrels	CFT	SMT F	SMT H	Reconstructed?	Reconstructible?
165645 5273011	Probe	2	2	1	0	No	No, hits too far
	Tag	3	7	0	0	Yes	Yes
164636 16204878	Probe	0	0	1	2	No	No, hits too far
	Tag	0	8	1	0	Yes	Yes
165795 5443702	Probe	3	6	0	0	No	No, hits too far
	Tag	1	6	1	0	Yes	Yes
164385 4847391	Probe	0	4	2	0	No	No, hits too far
	Tag	3	8	0	0	Yes	Yes
163121 35154278	Probe	0	0	3	0	No	No, hits too far
	Tag	2	8	0	0	Yes	Yes
166892 1830713	Probe	3	6	0	0	No	No, hits too far
	Tag	3	8	0	0	Yes	Yes
167953 9317412	Probe	0	5	3	0	No	No, hits too far
	Tag	3	8	0	0	Yes	Yes
167951 1004617	Probe	0	0	4	0	No	No, hits too far
	Tag	1	8	2	0	Yes	Yes
168382 70911483	Probe	3	6	0	0	No	No, hits too far
	Tag	5	8	0	0	Yes	Yes
168618 1461725	Probe	2	4	1	0	No	No, hits too far
	Tag	0	8	0	0	Yes	Yes
168619 2445580	Probe	3	3	2	0	No	No, hits too far
	Tag	3	8	0	0	Yes	Yes
169521 3463103	Probe	1	2	2	0	No	No, hits too far
	Tag	3	8	0	0	Yes	Yes

Invalid tracks:

Run/Event	Electron	SMT Barrels	CFT	SMT F	SMT H	Reconstructed?	Reconstructible?
164216 83479647	Probe	0	1	3	0	No, invalid	No
	Tag	1	7	0	0	Yes	Yes
164018 11142735	Probe	0	1	4	0	No, invalid	No
	Tag	3	8	1	0	Yes	Yes
164040 18660971	Probe	4	5	0	0	YES	Yes
	Tag	2	8	0	0	Yes	Yes
164083 35308948	Probe	0	0	2	1	No, invalid	No
	Tag	1	8	0	0	Yes	Yes
168525 19495531	Probe	4	5	1	0	YES	Yes
	Tag	4	8	0	0	Yes	Yes

Too few hits to reconstruct track:

Run/Event	Electron	SMT Barrels	CFT	SMT F	SMT H	Reconstructed?	Reconstructible?
165765 36883677	Probe	0	3	1	0	No	No, too few hits
	Tag	3	8	0	0	Yes	Yes
165686 45005141	Probe	0	2	2	0	No	No, too few hits
	Tag	2	8	1	0	Yes	Yes
164382 3507437	Probe	0	2	0	0	No	No, too few hits
	Tag	0	7	0	0	Yes	Yes
166484 14657490	Probe	0	1	0	1	No	No, too few hits
	Tag	0	0	3	2	Yes	Yes
166483 3946198	Probe	0	0	0	1	No	No, too few hits
	Tag	0	7	0	0	Yes	Yes
166505 40748533	Probe	0	0	0	1	No	No, too few hits
	Tag	0	8	1	0	Yes	Yes
163172 49593518	Probe	0	0	1	1	No	No, too few hits
	Tag	0	7	0	0	Yes	Yes
166776 115353883	Probe	0	6	1	0	No	No, too few hits
	Tag	0	8	0	0	Yes	Yes
164605 6649931	Probe	0	0	2	0	No	No, too few hits
	Tag	0	8	0	0	Yes	Yes
164080 30329930	Probe	0	7	1	0	No	No, too few hits
	Tag	1	5	0	0	Yes	Yes
164080 30329930	Probe	0	7	1	0	No	No, too few hits
	Tag	1	5	0	0	Yes	Yes
164095 44036204	Probe	0	1	1	0	No	No, too few hits
	Tag	4	8	1	0	Yes	Yes
166872 41058810	Probe	0	5	1	0	No	No, too few hits
	Tag	2	8	0	0	Yes	Yes

Too few hits to reconstruct track:

Run/Event	Electron	SMT Barrels	CFT	SMT F	SMT H	Reconstructed?	Reconstructible?
166898 16826502	Probe	0	3	2	0	No	No, too few hits
	Tag	1	8	0	0	Yes	Yes
168732 17138782	Probe	0	4	1	0	No	No, too few hits
	Tag	1	8	0	0	Yes	Yes
167663 70873322	Probe	0	3	0	0	No	No, too few hits
	Tag	0	8	0	0	Yes	Yes
167663 71845529	Probe	0	3	0	0	No	No, too few hits
	Tag	0	8	1	0	Yes	Yes
167807 102734040	Probe	1	2	1	0	No	No, too few hits
	Tag	3	8	0	0	Yes	Yes
168149 3637743	Probe	0	0	2	0	No	No, too few hits
	Tag	0	8	0	0	Yes	Yes
168153 21003252	Probe	0	1	0	1	No	No, too few hits
	Tag	0	5	0	0	Yes	Yes
168149 4360345	Probe	1	1	1	0	No	No, too few hits
	Tag	3	7	1	0	Yes	Yes
168152 20346262	Probe	0	1	1	0	No	No, too few hits
	Tag	0	8	0	0	Yes	Yes
168152 15671740	Probe	0	4	1	0	No	No, too few hits
	Tag	2	8	0	0	Yes	Yes
168640 1406155	Probe	0	0	0	1	No	No, too few hits
	Tag	0	8	0	0	Yes	Yes
168659 21057268	Probe	0	4	1	0	No	No, too few hits
	Tag	0	8	0	0	Yes	Yes
169183 11774110	Probe	0	5	1	0	No	No, too few hits
	Tag	2	8	0	0	Yes	Yes

Too few hits to reconstruct track:

Run/Event	Electron	SMT Barrels	CFT	SMT F	SMT H	Reconstructed?	Reconstructible?
168988 16788080	Probe	0	0	1	0	No	No, too few hits
	Tag	4	8	0	0	Yes	Yes
169247 16014181	Probe	0	5	0	0	No	No, too few hits
	Tag	0	7	0	0	Yes	Yes
169224 768975	Probe	1	3	1	0	No	No, too few hits
	Tag	3	7	1	0	Yes	Yes
169200 2352043	Probe	0	1	1	0	No	No, too few hits
	Tag	0	8	0	0	Yes	Yes
169247 14340879	Probe	0	0	0	1	No	No, too few hits
	Tag	0	8	2	0	Yes	Yes
169261 9325069	Probe	0	4	0	0	No	No, too few hits
	Tag	2	8	0	0	Yes	Yes
169264 25341783	Probe	0	0	1	1	No	No, too few hits
	Tag	5	8	0	0	Yes	Yes
169640 6053332	Probe	0	0	0	2	No	No, too few hits
	Tag	0	8	1	0	Yes	Yes
169298 23688912	Probe	0	0	0	1	No	No, too few hits
	Tag	0	8	0	0	Yes	Yes

Conclusion

Some of the missing tracks from the "probe" electrons

can be reconstructed by slight variations of the algorithm:

- Require 3+ hits in **both** SMT barrels and disks, not only in barrels

  or only in disks $\Longrightarrow$ diminish tracking inefficiency by 13%

- AND allow hits to be up to 4σ away from the track

  $\Longrightarrow$ diminish tracking inefficiency by 18%

- Increase sample by factor of $\approx 2 \Longrightarrow$ tracking inefficiency decreases by 12%

- Number of reconstructed tracks per event increases by 37%

- Would be interesting to check number of fake tracks in MC $\Longrightarrow$ to be done

- Processing time increases by approximately factor of 2

- Allow for 2 hits in SMT (barrels and disks) if CFT has 4+ hits

  $\Longrightarrow$ still to be investigated